carbide, WC, or the tungstide, Fe_2W, or in both forms according to the percentage of tungsten and carbon. In the normal state the tungsten carbide and iron carbide exist as a double carbide, $4Fe_3C.WC$, which has its critical point at 400° C. as compared with 725° C. for pure iron carbide. Above the Ac_1 point this double carbide dissociates into its components, but if the maximum temperature is not very high these recombine during cooling, and are deposited from solid solution at 400° C., forming a eutectoid with the ferrite. Above 1100° C. the following reaction occurs,

$$WC + 5Fe = Fe_3C + Fe_2W,$$

and during cooling the lowering of the transformation points occurs in consequence of the dissolved tungstide in austenite. The greater the carbon concentration in the system, however, the less does the above reaction proceed.

The lowering of the Ar_1 transformation due to heating increases with maximum temperature, and this depends on the tungsten, but not on the carbon content. Above 9 per cent. of tungsten, however, corresponding with the maximum solubility of this metal in iron, the lowered Ar_1 point is constant at about 440° C. If, now, a specimen which has a lowered Ar_1 point be reheated just beyond the Ac_1 point (about 900° C.), and then cooled, the transformation takes place at the normal point. This is due to the fact that tungsten carbide is formed in the Ac_1 range according to the reaction,

$$Fe_3C + Fe_2W = WC + 5Fe,$$

and during cooling the recombination of the tungsten carbide with the remaining iron carbide occurs. The authors are to be congratulated on their careful magnetic and metallographic analyses, which have enabled them to present a clear and very plausible conception of the chemical, structural, and phase changes which occur in tungsten steels both on heating and cooling.

H. C. H. C.

FUEL ECONOMY.

THE economical use of coal has been referred to frequently in these columns, but with all the various proposals for its more efficient application for power production the possibilities of effecting marked economies with existing boiler-plants have not been fully appreciated. In the columns of *Engineering* (July 12 and 19) Mr. D. Brownlie gives data of the examination of 250 boiler-plants, comprising 1000 boilers and using annually more than two million tons of coal. Seventy-six per cent. of the plants were hand-fired, the average net efficiency being 57·8 per cent.; the remainder, mechanically fired, show an efficiency of only 61·4 per cent. Only 9·6 per cent. of the plants show a higher efficiency than 70 per cent. Certainly these figures indicate very bad practice, for a net working efficiency of 75 per cent. may well be aimed at. Reorganisation of the plants examined to reach this figure would alone entail a saving of 430,000 tons of coal annually; throughout the country it would possibly lead to a saving of 15,000,000 to 20,000,000 tons. As Mr. Brownlie points out, "the question of the economical generation of steam will always be a very important part of the greater national scheme of coal economy, even if all the power of the country is generated by gas-engines and the by-products of the distillation of coal." As a large part of the power will undoubtedly be steam-generated in existing plants for many years to come, the improvement of the efficiency of these plants is urgently called for during the period which must elapse before the general reorganisation of the whole system of power production can be carried out.

Further evidence on fuel economy is contained in Bulletin No. 31, Circular 7, of the University of Illinois Engineering Experiment Station. This bulletin deals with the operation of hand-fired power plants, and the matter is presented in a manner readily understood by those who are not experienced engineers. About 6,000,000 tons of coal are consumed annually in Illinois in operating hand-fired power plants, and it is believed to be within the limits of practical attainment to effect a saving of from 12 to 15 per cent. of this fuel. Descriptions and drawings are given of simple appliances and the methods of using them explained, whereby the men who fire the coal may obtain precise information regarding the best working conditions for given steam consumptions. With proper attention these appliances enable the correct working conditions to be reproduced at any time, and also give evidence which leads to the detection of defects in the plant which would not otherwise be suspected. The section dealing with the storage of coal is of interest, and contains a very suggestive statement:—"Do not undertake to store coal until you are sure you know how to do it properly and safely." The circular has been compiled by a committee of the University authorities, aided by an advisory committee including several well-known names, and can be commended to the notice of all who desire to introduce scientific control in their boiler plants.

SALARIES IN SECONDARY AND TECHNICAL SCHOOLS, ETC.[1]

THE chief duty of this Committee, as defined in the terms of reference, was "to inquire into the principles which should determine the fixing of salaries for teachers in secondary and technical schools, schools of art, training colleges, and other institutions for higher education (other than university institutions)." They were specifically asked not "to consider the question of the amounts by which existing salaries should be improved."

Progress in the higher education of the nation depends, in the first instance, upon attracting and retaining, by means of adequate salaries and suitable salary scales, the services of the most capable and highly qualified teachers. The present rates of payment fail to secure this. The report states (p. 52) that the average salary of 3350 full-time assistant masters in 404 grant-aided boys' secondary schools in England and Wales on January 31, 1917, was only 187*l.* per annum. The average salary of 4294 assistant mistresses in similar schools was 130*l.* per annum. Out of 1050 secondary schools in England and Wales receiving grants from the Board of Education, in only 460 of these schools were salaries regulated by definite scales in January, 1917. Salary scales were, in general, only short scales covering a period of five or six years, the average maximum for graduates (men) being only 196*l.* 7*s.* The information in the report respecting salaries in technical schools, polytechnics, etc., is much less detailed and precise (p. 41). It would appear, however, that on March 31, 1914, the average salary of heads of departments and assistant teachers in these institutions was about 180*l.* per annum.

In view of the inadequate salaries just mentioned, especially with the higher cost of living, increased taxation, and the more generous remuneration now offered by commerce, industry, and the State services, it is no wonder, even allowing for certain recent improvements, notably in London, that the Committee

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[1] Report of the Departmental Committee on Salaries in Secondary Schools, Technical Schools, etc. (Cd. 9140.) (H.M. Stationery Office.) Price 6*d.* net.

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reports :—"We have no doubt that a very great increase of salaries is necessary . . . it has been brought home to us that the teaching services are experiencing increasing difficulties in attracting a reasonable share of the young men and women who give evidence of outstanding ability." This is felt more particularly in the technical schools, where the leakage from the profession and the difficulty of obtaining new teachers, due to the low salaries, the absence of salary scales, and the higher payment offered in industry, is raising serious obstacles to the development of technical education.

The principal recommendations of the Committee are as follows :—

(*a*) *Secondary Schools* (p. 25).—A minimum initial salary for (graduate) teachers in all secondary schools in receipt of public money should be fixed by the Central Authority, and a minimum amount prescribed at a later stage in the teacher's career. Salaries of assistant teachers should be regulated by scales. They should be such that teachers receive a substantial salary at the age of thirty-two or thirty-three, with increments continuing up to the age of about forty-two or forty-three. Normally, increments should be annual and automatic (subject to reasonable conditions as to efficiency). Equality of pay for the two sexes would, in existing circumstances, lead to one being underpaid and the other overpaid. No differences in salary should be made upon the basis of the subject taught or the size of the school. The possession of a high degree or other special qualification of a scholastic character may be recognised by placing its holder at a point on the scale above that which he would otherwise occupy. Heads of departments and assistants performing special duties should be remunerated by additions to their salary.

(*b*) *Technical Schools.*—Full-time assistant teachers of senior and advanced students, who are graduates or have qualifications equivalent to graduation, should be paid by scale at as high a rate at least as is paid in secondary schools, higher remuneration being given in exceptional cases where a teacher's qualification consists of long works experience and high technical knowledge. The salary may be determined by what will induce him to leave his occupation, otherwise the scale should be similar to that of the secondary-school teacher. The salaries of artisan teachers will be settled in the main by competition with industry.

The above recommendations respecting salaries in technical schools, bringing the payment of the full-time assistant lecturer up to that of the secondary-school teacher, would mean a great advance if carried into practice. Thus in London the assistant lecturer in a technical school or polytechnic rarely rises above 250*l.*, whereas the secondary-school teacher may rise to 400*l.*, or 450*l.* in special cases.

The Committee deals also with salary scales in schools of art, training colleges, etc., in a similar manner to its proposals relating to secondary and technical schools. An important general recommendation respecting the application of new scales to existing teachers states that this should not be too long drawn out, and there should be no avoidable delay in giving to every teacher some immediate and substantial instalment of any intended advance.

The proposals of the Committee, if carried into effect, would go far to remove one of the chief obstacles to the improvement of the higher education of the nation. There still remains, however, as regards salaries, the not unimportant question of the salaries of assistant lecturers in university colleges and similar institutions. Despite much criticism and a certain amount of agitation, these salaries still remain in a most unsatisfactory condition, even when compared with the new maximum salary of the L.C.C. elementary-school class-teacher (240*l.* or 300*l.*), or that of the London secondary-school assistant teacher (300*l.* non-graduate, 400*l.* or 450*l.* graduate).

J. WILSON.

HIGH-TEMPERATURE PROCESSES AND PRODUCTS.[1]

IN comparing workshop processes at present in use with those employed twenty years ago, many striking changes may be noted, all tending to cheaper and more rapid production. It will be found, on examination, that some of the most important of these changes are due to the utilisation of high-temperature processes, or to appliances in which new materials produced at high temperatures are employed.

At the present time, when the economic generation of electricity in this country by the aid of large, central power-stations is under consideration, the present and future importance of high-temperature processes and products cannot be too strongly emphasised. In any scheme that may be evolved, provision should be made for electric-furnace work on the large scale, as otherwise we shall remain, as heretofore, dependent upon other countries for many essential materials.

One of the most recent applications of the oxy-hydrogen flame is to the spraying of metals on to cold surfaces. In what is known as the Schoop process the metal, in the form of wire, is fed into the interior of the flame, where it is melted and then blown by compressed air, in a state of very fine division, on to the surface to be coated. The arrangement is such that when the size of the flame is increased or decreased, the feed of wire is changed simultaneously, so that the rate of deposit per unit area is constant. The finely divided metal fills all the interstices of the surface upon which it impinges, and becomes firmly attached; and by continuing the process any desired thickness may be deposited.

The thermit reaction has also been applied to the production of pure metals, and has proved of great value in cases where it is necessary to secure a product free from carbon. In the manufacture of special classes of steel in which manganese or chromium is used, it is desirable that these elements should be free from carbon, in order that the final carbon content may be regulated to any desired amount in the finished product. As prepared by furnace methods, these metals always contain carbon to a greater or less extent, and hence for high-class steel the carbon-free metals produced by the thermit method are preferable, although more costly.

Before the war the thermit industry was in German hands, and it is a matter for congratulation that the present British proprietors have been able to reproduce practically all the compositions which previously were imported. This is an excellent example of the value of research in applied science.

The rapid increase in the output of electric steel is due to several causes, chief amongst which are (1) the superior properties of the product, (2) the possibility of producing steels according to a given formula without difficulty, (3) the greatly reduced loss from oxidation of light steel scrap fed into the mixture, and (4), which applies specially to Britain, the possibility of obtaining a cheap supply of energy in certain localities. When all these factors are taken into account, high-grade steel can be produced more

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[1] Abridged from Cantor Lectures delivered before the Royal Society of Arts in January and February, 1918, by Mr. C. R. Darling.

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